Aguinaldo dos Santos [UFPR]

Assessing the information needs on production process within the construction industry

process transparency, information requirements, innovation

The present paper analyses the usage level of one of the core heuristic for increasing transparency in production systems: incorporating information into the production process. This research brings a different perspective to the design information community by presenting the point of view of production management. The data collection was carried out within six case studies in Brazil and England and adopted a pattern-matching analytical approach. The empirical evidence showed that construction makes very limited use of such an approach despite the problems caused by the lack of information among the workforce. Further developments have to be carried, aimed at the creative installation of information in equipment and materials in order to make the distribution channels more compatible with the continuous movement of construction workstations.

1. Introduction

Increase of transparency means to increase the ability of a production activity to communicate with people. This is one of the core principles behind a number of managerial methodologies and techniques such as Visual Management, Kanban, 5S programs, Andon, Poka-yoke, and so on.

Transparency can be used as an instrument to increase the motivation of workers for improvement, reduce the propensity of errors and, most certainly, increase the visibility of errors (Koskela, 1992). The manufacturing literature shows a list of other advantages relating to the implementation of transparency, such as (Greif, 1989):

- *Simplification and greater coherence in decision making;*
- *Stimulation of informal contacts throughout different hierarchical levels;*
- *Contribution to introduction of decentralization policies;*
- *Helps to broaden employees participation and autonomy in management;*
- *More effective distribution of responsibilities;*
- *Increase in employee morale;*
- *More effectiveness of production scheduling;*
- *Simplification of production control systems;*
- *Rapid comprehension and response to problems.*

The way in which information is organized for accessibility is the distinguishing feature of transparency as portrayed in modern theories. In conventional communication, information is transmitted in a “push” mode and the user has little or no control over the amount and type of information that is transmitted or received. In contrast, in the new paradigm nothing is transmitted: an information field is created which can be “pulled” by any person at any time (Greif, 1989). This is a fundamental move from the usual silent production process to a more communicative one, more selfexplanatory, self-ordering, self-regulating, and self-improving (Galsworth, 1997).

Production systems operating in competitive environments should no longer lead to loss of time with people searching for information. According to Galsworth (1997), information should be part of the process, as physically close as possible, pre-set at the point-of-use, fresh and available at a glance, without the need of people to ask questions or spend time processing it. In short, the process itself should be able to inform its state.

A transparent (or visual) workplace/process is characterized by a certain dualism, existing simultaneously, communication directed toward a group’s internal need and messages to people outside the workplace (Greif, 1989:27; NKS, 1991:4). In an ideal situation, even a lay visitor should

be able to understand what is happening in any production process and, consequently, be able to identify problems. This definition goes against traditional ways of thinking and that itself presents an opportunity for innovation.

The present research has investigated the level of effective usage of one core heuristic to implement transparency into production processes: “incorporating information into production processes”. The next sections describe this implementation approach and its context.

2. Heuristics

Context

The literature presents five main approaches for promoting process transparency:

- *Reducing the Interdependence between Workstations: when two or more different professionals have to work in the same area the immediate consequence is usually an increase in the degree of disruption and cluttering. This often makes it more difficult to understand and control such environments. One of the approaches used to minimise the occurrence of these situations is to reduce the interdependence between production units.*

- *Use of Visual Controls Enabling Immediate Recognition of Process Status: visual controls can give an important contribution to enhance efficiency of production systems. The easy and fast identification of waste, or any other process problems, helps enabling and promoting continuous improvement activities. For instance, appropriate visual controls should be able to help people to identify whether or not boxes of a certain item are where they should be, or if they have exceeded the maximum limit of a required quantity. In an ideal situation, anyone should be able to detect or avoid errors like this and, thus, contributing to improve the process performance.*

- *Making the Process Directly Observable: according to the definition of transparency, even people not familiar with the production environment should easily understand how the process works just by looking at it. One of the approaches for obtaining this is by making the process directly observable through appropriate layout planning, illumination or appropriate planning of the workstation flow. The layout and flow of process and operations has to be planned to allow observation for as many perspectives as possible. With this practice in place, operators should be able to understand why the parts of the preceding workstation are getting late or why the next workstation has stopped the work. In cellular manufacturing, for instance, the start of a process is located as close as possible to the end of that process, making it easier to follow the flow materials (Galsworth, 1997).*

- *Maintaining a Clean and Orderly Workplace: When a workplace is clean, safe, and orderly, the worker can relax and do his/her work more efficiently. The most famous and successful method of keeping a clean and orderly workplace is known as “5S”. The term 5S is a familiar term among “world-class companies” and refers to the five traditional housekeeping practices that are part of the daily routine of every Japanese household. From the mid-1950s, these practices became corporate imperatives in Japanese companies (Seiri: proper arrangement, organization; Seiton: orderliness, selecting locations; Seiso: cleanliness; Seiketsu: cleaned up, neatness; Shitsuke: discipline, good conduct).*

- *Rendering Invisible Attributes Visible Through Measurements: in the strict theoretical sense, transparency means the separation of the network of information present in the production system from the physical production system itself (Greif, 1989). The network of information is always implicitly there and can be externalised through measurements. So, for instance, attributes such as quality of production workmanship, waste or productivity are invisible unless they are measured and transformed into performance indicators.*

- *Incorporating Information into the Process: this is the approach focused on this paper (see next section for full description).*

Incorporating information into the process

The move from an environment of silent disorder to an environment of informative visual order starts by asking questions such as “What do I need to know?” and “What do I need to share?” In that sense, the incorporation of useful information throughout the production system is a necessary step to reaching a self-explanatory and self-regulating environment. This is the most

passive form of transparency, since it gives helpful information without necessarily demanding obligatory adherence (Galsworth, 1997).

The content of information displays can range from specific recommendations about products or processes to general information about the company plans (e.g. next contracts). Obviously, information needs to be helpful and meaningful to workers. Defects display boards, defective storage part areas, general statistics about the process or even illustrative videos from suppliers are examples of this informative role of visual communication (Greif, 1989). In standardisation programs, information displays can play an important role in promoting the ownership of documents (adherence), improving the visibility of results (observation) or helping the follow-up of improvement ideas (modification).

Appropriate information can also help customers “get smart” about the production processes. For example, some manufacturing companies post the name of each machine and the operators who run the machine, and even a photograph, along with the number of years that this person has worked for the company. This brings a sense of commitment to the workforce and can also have a considerable positive effect on the image of the company. Another example of a device to help the customer “get smart” about production is the “Where-I-am Maps” that inform the customer of his/her position in relation to other locations within the system (Galsworth, 1997).

Incorporation of information into the process can play an important role on the workforce perception of effectiveness. Its implementation should be based on intention, motivation and voluntary adherence; it will only work when one wants to become a recipient of that information. Setting up a computer network, developing a system for routing inter-departmental memoranda, or creating an in-house newspaper is possible in any company but it is a waste of money if staff is not self-motivated to use the system or interpret the information. Managers are often tempted to display indicators in work areas but there is no value in doing so if the work-team involved has no concern about its performance (Greif, 1989:174).

Steudel & Desruelle (1992) argue that people have a bias to remain silent when anything goes wrong, and this tendency is even more pronounced when the person who signals a problem might be blamed for it. In this respect, the majority of problems in the production systems are the responsibility of management rather than the workers at whom the posters and slogans are normally aimed. Posters and slogans can create adversarial relationships if there is no genuine purpose to help, advise or inform the workforce when there is a problem within the organisation (Deming, 1988).

3. Research method

Having identified the main issues in the field, the first phase of this work involved a more thorough literature review focusing on some specific core principles underlying contemporary production management. The objective of this revision was to obtain the basic theoretical framework that would later be the key reference point, or benchmark, against which all the empirical data would be analysed.

In the second phase the researcher conducted an empirical investigation to validate the proposed theoretical framework in practice. Due to the type of research questions asked, and the importance of obtaining information from real-life contexts, a multiple “case study” approach was adopted. The data collection used a standardised observational protocol and was carried out in six construction sites of two different countries (Brazil and England). In addition, isolated construction “best practices”, collected around the world, have been assembled into a “meta-case” to supply complementary information for those instances where the case studies did not produce sufficient empirical evidence. The case studies and the meta-case constitute the principal research material used during the validation of the theoretical framework.

The third phase of this work focused on the intra-case study analysis, with emphasis on the interrelationships between theoretical propositions, and a cross case study analysis, aimed at testing the validity of each of the isolated theoretical proposition. This phase used the pattern-matching approach described in Santos, Powell & Hinks (2001).

4. Results & analysis

Observational focus

The researcher's attention focused here on any display of information directly relating to bricklaying.

The identification of information displays took usually two days, and started with the drawing of a process flow-chart. The researcher then scrutinized every process stage, the equipment used in the workstations, pathways, workplaces and any material or component delivered on site. Open-ended interviews, and daily conversations with the workforce, brought further insights into the actual use of the information displays identified.

Key indicators

The total "number of information displays", particularly those presented with respect to information boards, or occurring in products delivered on site, has been adopted as the main indicator to assess each case study regarding this approach. When this indicator is placed against the "number of process stages" it can show the relative intensity of information throughout the bricklaying process in each case study.

Expected behaviour and boundaries of indicators

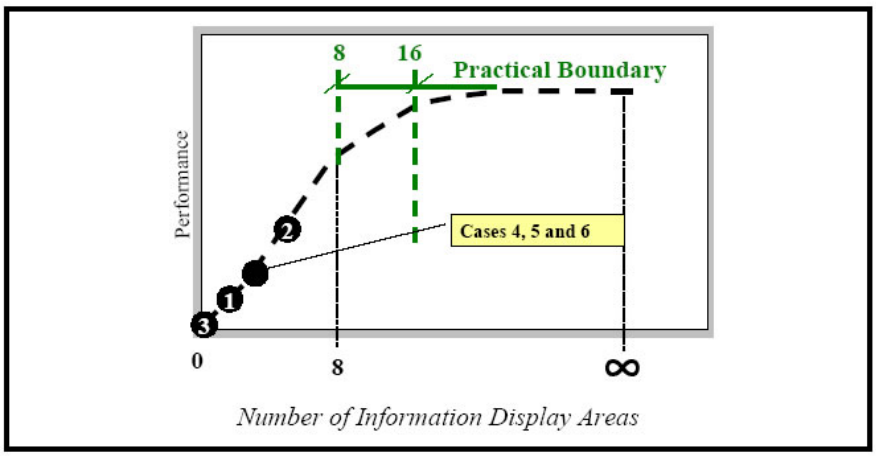
The literature does not discuss any criteria for the level of information that should be present in the production environment. Inference on Greif's (1989) and Galsworth's (1997) writings suggests that every process stage should have an information display. Thus, for analytical purposes, this research admits the minimum quantity of information displays as equal to the shortest number of process stages identified among the case studies (eight). The upper limit of information displays has been admitted as double of this minimum value.

General pattern across all cases

All case studies presented a level of information in the production environment below the minimum value established for this research. The best case study presented information displays in only half of the process stages. Furthermore, as Table 1 shows, boards were the only media used to displays process information. None of the components, material and equipment flowing across the site has displayed useful process information for bricklayers.

Table 1: Performance of Case Studies Regarding Installation of Information into the Production Environment

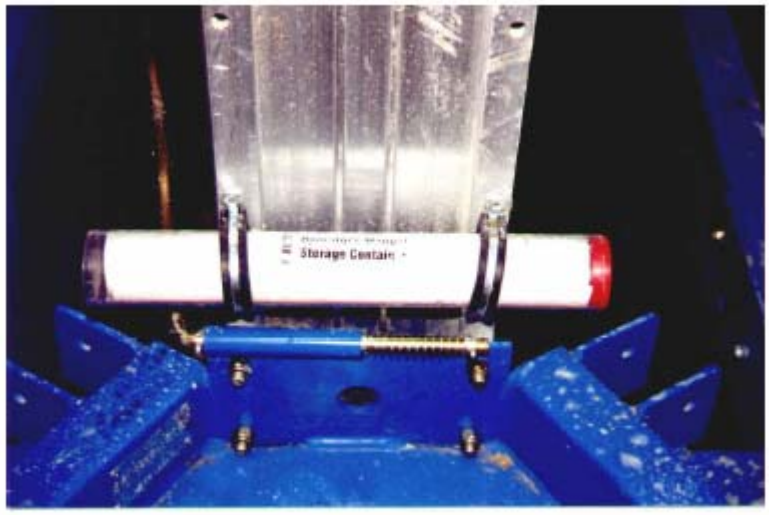
Indicator	Case study					
	1	2	3	4	5	6
Number of Days Observed	2	2	2	2	2	2
Number of Boards Displaying Process Information	1	4	0	2	2	2
Number of Products Displaying Process Information	0	0	0	0	0	0
Number of Process Stages	11	8	8	8	12	12
Number of Literal Replication	1	4	0	2	2	2



The need for displaying information was evident since bricklayers revealed great lack of knowledge on the basic aspects of the products and equipment they handled everyday. When questioned about the procedures for maintaining their own equipment, for instance, they generally argued that they did not have sufficient knowledge on the subject. Empirical evidence available in the meta-case showed that the equipment of workstations could be the channel to present such information.

Figure 1 shows a maintenance manual attached to the equipment that it refers to. The equipment consists of manual lift used to transport pallets of bricks. With this 'maintenance manual' attached to this equipment, any technical information regarding maintenance problems could be easily obtained in the workstation itself, when and where necessary.

Figure 1: Literal Replication of Installation of Information into the Production Environment (Meta Case/England)



Site managers argued that there was not much information displayed to bricklayers because the process was relative simple and, furthermore, handling of the most critical information was the manager's responsibility. Consequently, bricklayers did not have sufficient knowledge about the workstation flow or date of deliveries on site. They relied on the site manager for such decisions and he did not normally take any responsibility for problems occurring in the workflow or layout.

Individual case study reports

Case study 1

This site presented only one information display, despite the existence of eleven bricklaying process stages, as Table 1 shows. Yet, the only information display identified was inside the manager's office where bricklayers rarely have access. The tools and equipment used

on this site were well maintained, but did not have any information attached regarding their use. None of the suppliers had included, in their packing system, information that could lead to better, more effective and more efficient bricklaying practices.

Case study 2

The four information displays identified in this case study have no direct effect on the main processing activity. Safety was the main topic of these displays. This empirical evidence consists of a blackboard fixed in the lunch area. Site managers used this blackboard to communicate a variety of information to the workforce, mainly regarding safety precautions.

Despite the lack of information displays, the workforce revealed satisfactory knowledge regarding workflow, maintenance of equipment and general characteristics of material. Daily observations revealed that the daily direct contact between the workforce and site manager have compensated for the lack of information displays.

Case study 3

This construction site did not have any information displayed throughout the bricklaying process or surroundings, as Table 1 shows. The site manager centralized the control of information and even declared certain skepticism in showing information to the bricklayers. In his words "…all information that bricklayers could possibly need have already been supplied such as drawings, the date of payments and deadlines". He emphasized that the site office was always open to solve any queries or doubts that bricklayers might have. However, during the fifteen days of observations on this site there has been no exchange of ideas between the site manager and workforce.

Case study 4

Table 1 shows that this site presented only two "literal replications" throughout its eight process states. The consequences of not having sufficient information displays in the workplace, workstation or pathways was subtle, but easily captured when questioning new workers about their own process. Quite often, they were told what to do but did not know what was the purpose of such activities, or if there were any better ways of doing it. Information such as the typical quality problems, characteristics of materials and so on, could effectively help workers in this workstation to understand and improve their own practices in this construction site.

Case study 5

Only two information displays have been found among the twelve process stages mapped during the observational period on this site, as Table 1 shows. These information displays focused mainly on safety aspects of production and general administrative information. None of the equipment, components or material present on site contained useful process information despite the clear deficiency of knowledge among bricklayers and laborers on their own process. The site manager also agreed that more information should be given to the workforce. In this respect, best practice instruction could be incorporated into the products received on site in order to elevate the practices identified by the researcher to become part of everyday working.

Case study 6

This case study presented similar levels of information on the production environment as in Case study 5. The consequence in terms of transparency were also similar to that case since the open-ended interviews revealed that the workforce have little knowledge about managerial decisions affecting their workflow or even the technical aspects of bricklaying. Neither did they have any information on standard bricklaying procedures, despite the existence of written documents describing every step of the bricklaying process held in the site office. The site manager retained all information but did not seem to agree for the need to disseminate information in the workplace, or at workstations. In his view, bricklayers would not pay any attention to process information, because of their low level of formal education.

5. Concluding remarks

The analysis of case studies resulted in two main lessons:

1. Information displays were mostly used to transmit safety and administrative information despite the deficiencies in "know-how" identified among the workforce;

2. More information is required in material, components and equipment in order to adapt this approach to become the everyday of bricklaying.

There was an incompatibility between the characteristics of site display mechanisms and the characteristics of production in construction across all case studies. In this sense, construction processes demand better ways of exhibiting information in the workplace/workstation. Process information, like visual controls, should be incorporated in all the equipment, components and materials that move throughout the construction site. The constant movement of workstations is an automatic distribution channel for process information. Unfortunately, this is still not fully appreciated by construction managers and suppliers.

The distribution of information throughout the production environment demands a different relationship between managers and workforce. Greif (1997) argues that trust between both parties within a collaborative environment is one of the conditions to obtaining adherence from the workforce to the content of information. Hence, the reduced amount of information available in the construction sites analysed in this research reflects the environment of mistrust and poor teamwork between managers and workforce. In such a context, managerial decisions will always be questioned by the workforce. Therefore, an appropriate mechanism for discussions needs to be in place beforehand.

6. Conclusion

The installation of information in construction workplaces and workstations is a practical and viable alternative to increasing transparency according to the observations made in the case studies. However, the empirical evidence showed that construction makes very limited use of such an approach despite the problems caused by the lack of information among the workforce. Further developments have to be carried, aimed at the creative installation of information in equipment and materials in order to make the distribution channels more compatible with the continuous movement of construction workstations.

References

Galsworth, G. D. (1997), Visual Systems: Harnessing the Power of a Visual Workplace, New York: AMACOM, 320 p.

Greif, M. (1991), The Visual Factory: Building Participation through Shared Information, (Translated by L. Lockwood). Portland: Productivity Press.

Koskela, L. (1992). Application of the New Production Philosophy to Construction. Technical Report # 72. Center for Integrated Facility Engineering. Department of Civil Engineering. Standford: Standford University. 75 p.

NKS: Nikkan Kogyo Shimbun. (1991). The Factory Management Notebook Series. Visual Control Systems, v. 1, n. 2. (edited by Esmé McTighe) Portland: Productivity Press.

Santos, A; Powell, J.; Hinks, J. (2001). Using pattern-matching for the international benchmarking of production practices. Benchmarking an international journal, London: MCB University Press.

Steudel, H. J. and Desruelle, P. (1992), Manufacturing in the Nineties: How to Become a Mean, Lean, World-class Competitor, VNR Competitive Manufacturing Series.

About the author

Aguinaldo dos Santos is a Professor at the Design Department, Paraná Federal University (UFPR), Brazil. He has developed his undergraduate degree on Civil Engineering at UFPR. He also developed an MSc on Civil Engineering focused on production waste at Rio Grande do Sul Federal University, Brazil, and a PhD on Operations Management focused on lean production, carried out at Salford University, England. Currently he coordinates UFPR's Sustainable Design Research Center and supervises postgraduate students at both Mechanical Engineering as well as Civil Construction Postgraduate Course.